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ANNOTATED LIST OF SPECIES

Check List 15 (4): 629–640
https://doi.org/10.15560/15.4.629

PENSOFT

Fishes from lakes and tributaries of the Rio Santa Bárbara, Sapucaí-Mirim/Grande hydrographic basin, São Paulo, Brazil

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Abstract
Rio Santa Bárbara, a small tributary of the Rio Sapucaí-Mirim, has undergone severe human intervention over the past 80 years. We surveyed the ichthyofauna of this river, some surrounding lakes, and the Rio Potreiro, a tributary. Four campaigns were carried out, 2 in the dry season and 2 in the rainy season. We found 920 specimens at 12 sites and included 32 species belonging to 6 orders and 16 families. The order Characiformes was found to be best represented in our study, followed by the orders Cichliformes and Siluriformes. The family Characidae was the most numerous, followed by the families Cichlidae and Poeciliidae. A specimen of *Brycon nattereri* was collected from the Rio Santa Bárbara; this species is Critically Endangered in the state of São Paulo.

Keywords
Conservation, freshwater fishes, Neotropical biodiversity, upper Rio Paraná.

Academic editor: Felipe Ottoni | Received 21 December 2018 | Accepted 7 June 2019 | Published 9 August 2019

Citation: Diniz PB, Siqueira HO, Faleiros TO, Pereira NL, Senhorini JA, Esguícero ALH, Bertelli C (2019) Fishes from lakes and tributaries of the Rio Santa Bárbara, Sapucaí-Mirim/Grande hydrographic basin, São Paulo, Brazil. Check List 15 (4): 629–640. https://doi.org/10.15560/15.4.629

Introduction

The Sapucaí-Mirim/Grande hydrographic basin has a catchment area of approximately 9,000 km^2 and consists mainly of Sapucaí-Mirim, Canoas, and Carmo rivers. It is part of the upper Rio Paraná basin, a region considered to be a natural ichthyofaunistic province, with considerable endemism for some groups of fishes (Géry 1969) due to its particular geological formation (Castro et al. 2004). Current estimates are that there are more than 250 species in the Brazilian section of the basin (Langeani et al. 2007).

The Rio Santa Bárbara, a small tributary of the Rio Sapucaí-Mirim, is in São Tomás de Aquino, a city in the state of Minas Gerais (Fig. 1). It runs 60 km east to west and is a right bank tributary of the Rio Sapucaí-Mirim. On the banks of the Rio Santa Bárbara are the richest diamond deposits and the most fertile soils of the region, as well as a leisure spot called Cachoeira Maria Pia. The main tributary on the right bank of the Rio Santa Bárbara is the Rio Sapucaizinho, which is also known as the Rio Patrocínio (Bertelli 2012).

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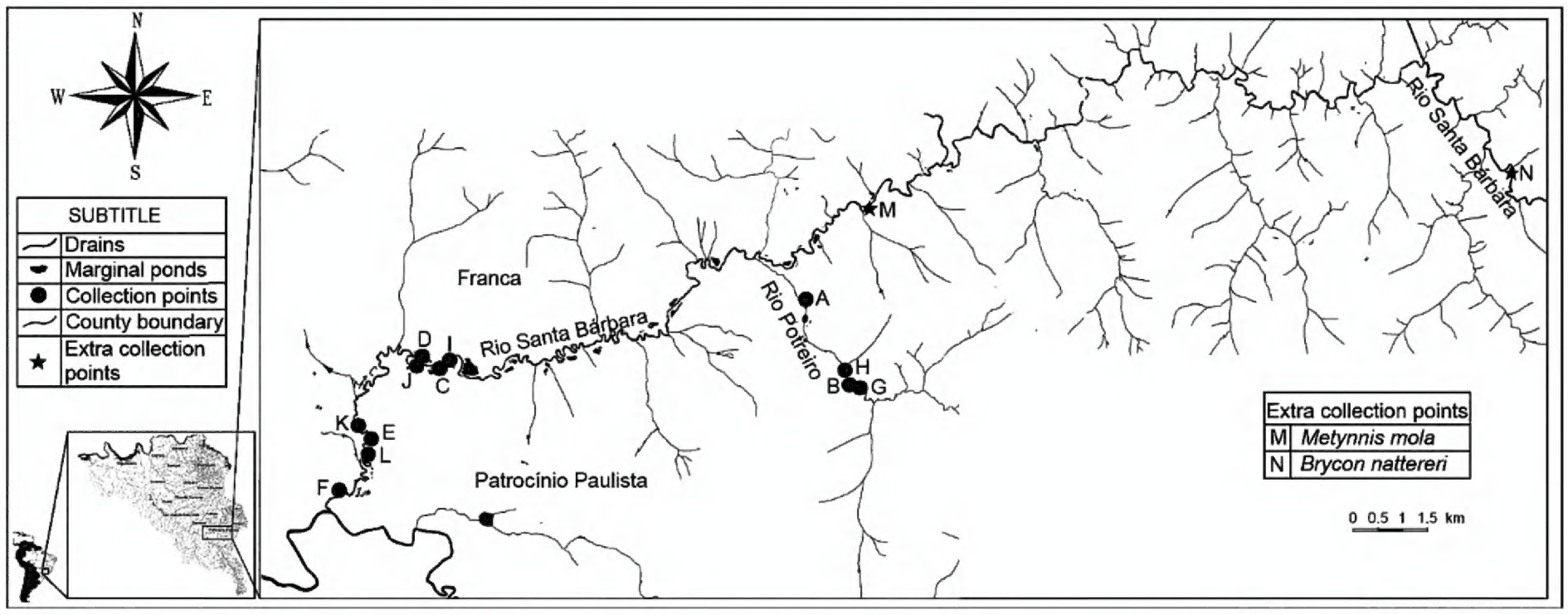

Figure 1. Location of Rio Santa Bárbara, Rio Potreiro, marginal lakes and sampled sites at each river. A, B, G and H at Rio Potreiro; C, D, I and J upper portion at Rio Santa Bárbara; E, F, K and L lower portion at Rio Santa Bárbara; M and N areas not initially selected.

The region has areas of waterlogging, with aquatic habitats transitioning to terrestrial habitat. Thus, the chemical, physical, and biological characteristics of this ecosystem and all its fauna and flora are directly influenced by floods.

According to Reis et al. (2016), there are an estimated 9,100 species of fish in Neotropical freshwaters, which corresponds to 24% of all fish species or 12.5% of the global diversity. Of this total, 166 species are known to occur in the state of São Paulo (Castro and Menezes 1998).

Six small hydroelectric power plants (SHP) have been built along the Rio Sapucaí-Mirim since the beginning of the last century (Retiro, Anhanguera, Palmeiras, São Joaquim, Dourados, and Esmeril). The first 5 are downstream of the mouth of the Rio Santa Bárbara. They are characterized by a deviation of the river, with small flooding area, and are therefore considered of less environmental impact (Habit et al. 2007), but they significantly interfere with the mobility of the ichthyofauna, especially during the reproduction period of rheophilic species. The Rio Santa Bárbara basin is part of Mogi/Pardo/Sapucaí-Mirim/Grande Action National Plan (PAN MPSG) (ICMBio 2017), a set of actions of the Brazilian government whose general objective is to recover the aquatic fauna in this region, with emphasis on threatened fish species.

We present a survey of the ichthyofauna of the Rio Santa Bárbara, mainly of its tributary, the Rio Potreiro and 6 connected lakes. As the first study of the ichthyofauna in this system, our inventory is especially important.

Methods

Study area. The collections were reached out in 4 sections of the Rio Santa Bárbara and 2 in the Rio Potreiro, besides 4 lakes of the Rio Santa Bárbara, 2 on the left bank and 2 on the right bank, and 2 lakes on the Rio Potreiro, 1 on the left bank and 1 on the right bank (Table 1, Fig. 2). Two areas were selected in the Rio Santa Bárbara, 1 upstream and 1 downstream of a sugar and alcohol mill, in order to verify if there is any impact of this facility on the ichthyofauna. We incorporated the Rio Potreiro in our study because it is more protected, far from the anthropic effects of sugarcane cultivation, the

Table 1. Sampling sites in Rio Santa Bárbara, Rio Sapucaí-Mirim, upper Rio Paraná basin, São Paulo state, Brazil.

Sampling sites	Latitude (S)	Longitude (W)	Notes	Photograph (Fig. 2)
A	20°43.32′	047°21.52′	Lake at right bank of Rio Potreiro	9, 9A
B	20°44.24′	047°21.00′	Lake at left bank of Rio Potreiro	8, 8A
C	20°44.01′	047°25.78′	First lake at left bank of Rio Santa Bárbara	1, 7, 7A
D	20°43.88′	047°26.99′	First lake at right bank of Rio Santa Bárbara	6, 6A
E	20°44.80′	047°26.62′	Second lake at left bank of Rio Santa Bárbara	5, 5A
F	20°45.33′	047°26.98′	Second lake at right bank of Rio Santa Bárbara	4, 4A
G	20°43.42′	047°21.55′	Upstream region of Rio Potreiro	2
H	20°43.25′	047°21.63′	Downstream region of Rio Potreiro	2
I	20°43.93′	047°25.69′	First upstream region at Rio Santa Bárbara	1
J	20°43.97′	047°27.00′	First downstream region of Rio Santa Bárbara	1
K	20°44.69′	047°26.73′	Second upstream region of Rio Santa Bárbara	3
L	20°44.86′	047°26.68′	Second downstream region of Rio Santa Bárbara	3
M	20°42.05′	047°13.31′	Unselect area	—
N	20°42.36′	047°20.77′	Unselect area	—

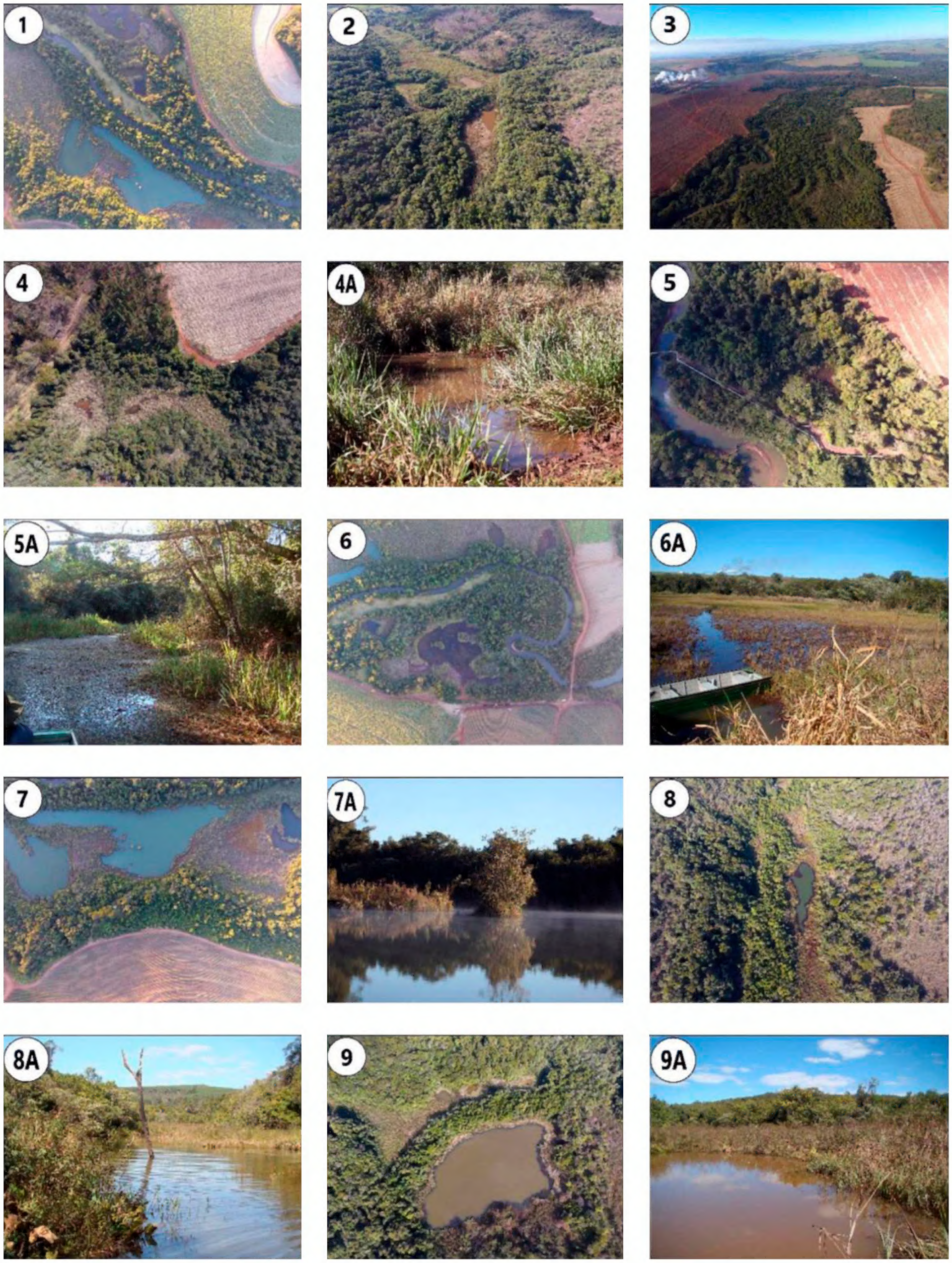

Figure 2. Sampling sites in Rio Santa Bárbara, Rio Sapucaí-Mirim, upper Rio Paraná basin, São Paulo state, Brazil. Details of the sites, see Table 1. Photos by Hatus Siqueira (1, 2, 3, 4, 5, 6, 7); Tâmer Faleiros (4A, 5A, 6A, 7A, 8, 8A, 9, 9A).

main culture in the region, and the discharge of domestic and industrial effluents.

Data collection. Four campaigns were carried out, 2 in the dry season (July–August; September 2017) and 2 in the rainy season (December 2017; March–April 2018). The collections were authorized by Chico Mendes Institute for Biodiversity Conservation (authorization for activities with scientific purpose no. 59737-1).

Sampling. The fishes were caught with 10 m long by 1.5 m high gill nets with meshes of 3, 4, 6, 7, 8, 10, 12, and 14 cm between opposing nodes. The nets were installed at dusk (between 4 pm and 6 pm) and left until the following morning (between 7 am and 9 am). The exposure time of the nets was on average 15 h. To better capture small species, samples with 800 × 1200 mm sieves (30 replications) were made along the edges of the lakes.

All captured specimens were counted and euthanized in a solution of clove oil (Eugenol, 2 drops/L; see American Veterinary Medical Association 2001). Those netted were separated into species lots and labelled. A part of each sample was fixed in 10% formalin for identification by a specialist and the others were frozen to serve as a sample bank of genetic materials and deposited in the Centro Nacional de Pesquisa e Conservação da Biodiversidade Aquática Continental (Instituto Chico Mendes da Conservação da Biodiversidade; ICMBio/CEPTA). The fishes collected with sieves were fixed in 10% formalin, labelled, and after 24 h, transferred to 70% ethanol. The fixed materials were deposited in the Laboratório de Ictiologia de Ribeirão Preto (LIRP), Universidade de São Paulo and is now part of the ichthyological collection.

Taxonomic identification and classification. Various sources were used for the taxonomic identification of the specimens. These included the identification keys by Castro et al. (2004) and Ota et al. (2018). We followed Reis et al. (2003) and Langeani et al. (2007) for the classification of species as autochthonous, allochthonous, or exotic.

Results

We collected 920 specimens in the Rio Santa Bárbara basin (see Materials examined). There were 32 species representing 6 orders and 16 families. The order Characiformes was best represented in our survey (62.5%), followed by the orders Cichliformes (12.8%), Siluriformes (11.7%), Cyprinodontiformes (11.0%), Gymnotiformes (1.7%), and Synbranchiformes (0.2%). The Characidae was best represented family in our survey (41.2%), followed by the families Cichlidae (12.8%) and Poeciliidae (11.0%) (Figs 3, 4).

In our analysis by habitat, lakes contributed 687 individuals (24 species, 6 orders, and 13 families), with the orders Characiformes (56.8%), Cichliformes (17.2%), and Cyprinodontiformes (14.7%) best represented. In lake habitats, the families with the most specimens were Characidae (42.6%), Cichlidae (17.2%), and Poeciliidae (14.7%).

In the Santa Bárbara and Potreiro rivers we collected 233 individuals, and only 3 were captured in Rio Potreiro, with the same methodology. We found 15 species in these rivers. Two orders and 9 families were represented; 79.4% are representatives of the order Characiformes and 20.6% of the order Siluriformes. The most representative families were Characidae (36.9%), Anostomidae (19.3%), Loricariidae (16.7%), and Curimatidae (15.5%) in these rivers.

We were able to identify 65 lakes, which 43 of them are permanent (remain full throughout the year in both dry and rainy seasons), 19 temporary (filled only in the rainy season), and 3 abandoned meanders. The last category of lakes are those that became disconnected from the main channel of the river due to changes in river dynamics, succession of the erosive process, and deposition along its course; they may be marginal lakes in advanced stage of sedimentation or early stage of swamp forest.

Order Characiformes
Family Anostomidae

***Leporinus friderici* (Bloch, 1794)**
Figure 5A

Original description. *Salmo friderici* Bloch 1794: 94.

Geographic distribution. Drainages of Suriname, Amazon basin, and Paraná-Paraguay system.

Materials examined. Vouchered materials: LIRP 15795, 15799, and 16074; Sampling site I of Table 1. Non-vouchered materials: Sampling sites H, J, K, and L of Table 1.

Identification. Elongated body; terminal mouth; premaxilla and dentary with 4 incisiform teeth, no maxillary teeth. Ground color silvery to yellowish; dorsal portion of iris red; longitudinal series of dark-brown spots on flank scales, horizontally elongated. Fins yellowish.

***Megaleporinus obtusidens* (Valenciennes, 1836)**
Figure 5B

Original description. *Leporinus obtusidens* Valenciennes, 1847: 9.

Geographic distribution. Paraná, La Plata and Jacuí, São Francisco and Parnaíba basins: Argentina, Brazil, Bolivia, Paraguay and Uruguay.

Materials examined. Vouchered materials: LIRP 15799; Sampling site I of Table 1. Non-vouchered materials: Sampling sites J and L of Table 1.

Identification. An Anostomidae representative with subterminal mouth; premaxillary and dentary bones with 3 incisiform teeth; silver colored body with 3 rounded spots over the lateral line. Dorsal fin whitish and pectoral, pelvic, anal, and caudal fins yellowish.

***Schizodon nasutus* Kner, 1858**
Figure 5C

Geographic distribution. Paraná, Paraguay, and Uruguay river basins.

Materials examined. Vouchered materials: LIRP 15763 and 15794; Sampling site I of Table 1. Non-vouchered materials: Sampling sites C, J, K and L of Table 1.

Identification. Body elongated; Mouth subterminal, with snout prominent; premaxilla and dentary with 4 teeth with tetracuspidated. Ground color silvery to yel-

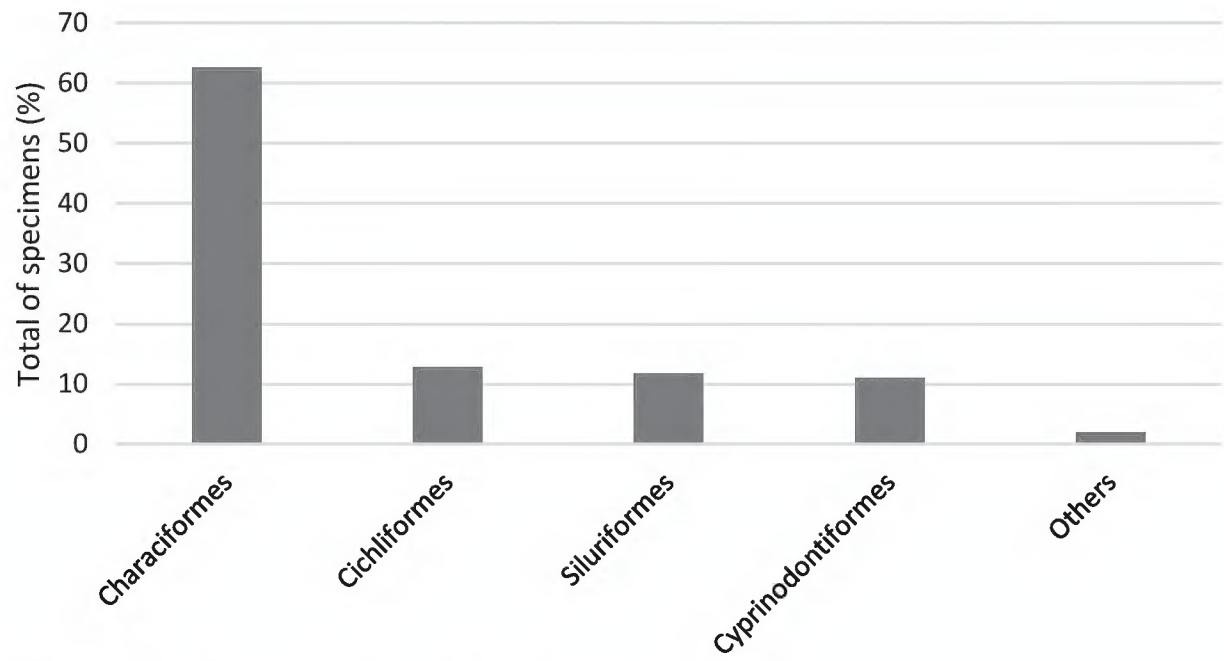

Figure 3. Percentages of the total number of specimens in each order.

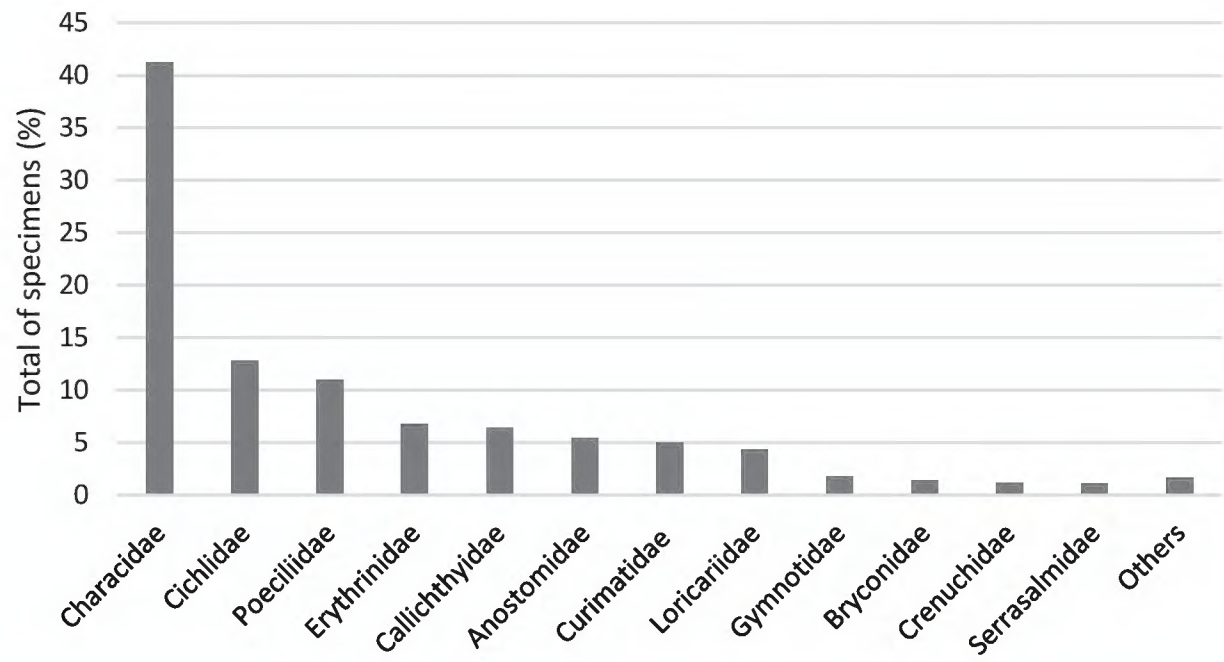

Figure 4. Percentages of the total number of specimens in each family.

lowish; black horizontally elongated blotch on caudal peduncle, extending to median caudal-fin rays.

Family Bryconidae

***Brycon nattereri* Günther, 1864**
Figure 5D

Geographic distribution. Upper Paraná and São Francisco river basins, Brazil.

Materials examined. Vouchered materials: LIRP 15717; Sampling site M of Table 1.

Identification. Terminal mouth; premaxila with 3 teeth rows; head with a rounded and obtuse profile; silver colored body without longitudinal stripes, with a humeral blotch and a caudal peduncle blotch extending into middle caudal-fin rays.

***Salminus hilarii* Valenciennes, 1850**
Figure 5E

Geographic distribution. Paraná, São Francisco, Tocantins, Amazonas, and Orinoco river basins.

Materials examined. Vouchered materials: LIRP 15792; Sampling site I of Table 1. Non-vouchered materials: Sampling sites J, K and L of Table 1.

Identification. Terminal mouth; premaxila with 2 teeth rows. Silver colored body with a transversal dark-brow stripe at the posterior region of the caudal peduncle, extending through the medial caudal-fin rays. All fins reddish.

Family Characidae

***Astyanax fasciatus* (Cuvier, 1819)**
Figure 5F

Original description. *Chalceus fasciatus* Cuvier 1819: 352, pl. 26.

Geographic distribution. Widely distributed in drainages from Mexico to Argentina.

Materials examined. Vouchered materials: LIRP 15733, 15752, 15753, 15769, 15780, and 15791; Sampling sites A, B, C, and I of Table 1. Non-vouchered materials: Sampling sites J, K, and L of Table 1.

Identification. Terminal mouth; premaxilla with 5 teeth in the internal row, outer with 4 or 5 teeth, dentary with 10–12 teeth, and maxillary toothless; 34–36 lateral-line scales; 24–28 anal-fin rays; black vertically elongated humeral blotch.

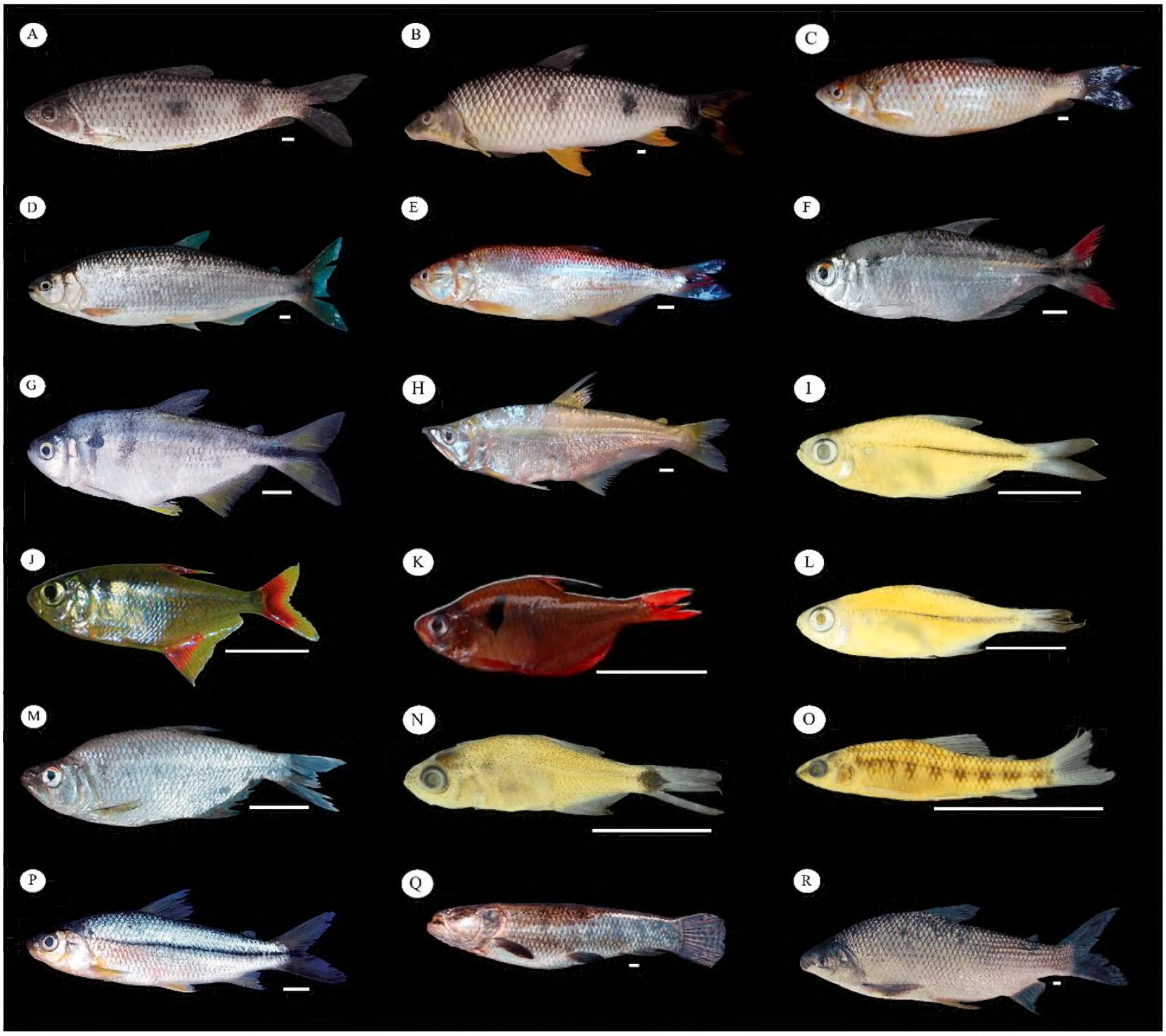

Figure 5. Representative samples of fish species collected in Rio Santa Bárbara, Sapucaí-Mirim/Grande hydrographic basin, São Paulo state, Brazil. **A.** *Leporinus friderici*, LIRP 15795, 272.46 mm SL. **B.** *Megaleporinus obtusidens*, LIRP 15799, 428.00 mm SL. **C.** *Schizodon nasutus*, LIRP 15763, 310.50 mm SL. **D.** *Brycon nattereri*, LIRP 15717, 285.00 mm SL. **E.** *Salminus hilarii*, LIRP 15792, 185.00 mm SL. **F.** *Astyanax fasciatus*, LIRP 15719, 125.00 mm SL. **G.** *Astyanax lacustris*, LIRP 15754, 107.00 mm SL. **H.** *Galeocharax gulo*, LIRP 15762, 255.00 mm SL. **I.** *Hemigrammus marginatus*, LIRP 15746, 37.45 mm SL. **J.** *Hyphessobrycon bifasciatus*, LIRP 15719, 32.72 mm SL. **K.** *Hyphessobrycon eques*, LIRP 15724, 25.91 mm SL**. L.** *Moenkhausia intermedia*, LIRP 15723, 34.60 mm SL. **M.** *Oligosarcus pintoi*, LIRP 15768, 51.47 mm SL. **N.** *Serrapinnus notomelas*, LIRP 15731, 26.79 mm SL**. O.** *Characidium zebra*, LIRP 15730, 18.77 mm SL. **P.** *Steindachnerina insculpta*, LIRP 15796, 115.00 mm SL. **Q.** *Hoplias malabaricus*, LIRP 15737, 360.00 mm SL. **R.** *Prochilodus lineatus*, LIRP 15800, 413.00 mm SL. Scale bars = 1 cm.

***Astyanax lacustris* (Lütken, 1875)**
Figure 5G

Original description. *Tetragonopterus lacustris* Lütken 1875: 131.

Geographic distribution. Eastern Brazil.

Materials examined. Vouchered materials: LIRP 15754, 15760, 15767, and 15793; Sampling sites A, B, C, and I of Table 1. Non-vouchered materials: Sampling sites J and L of Table 1.

Identification. Deep body; terminal mouth; inner row of premaxilla with 5 teeth, outer with 4 or five, dentary with 8–16, and no maxillary teeth. Lateral line complete, with 33–41 pored scales; transversal series above lateral line with 6–8 scale rows and below with 4–8 scale rows. Ground colour silvery; 1 black rounded humeral blotch followed by another vertically elongated humeral blotch. All fins yellow.

***Galeocharax gulo* (Cope, 1870)**
Figure 5H

Original description. *Cynopotamus gulo* Cope 1870: 565.

Geographic distribution. Upper Rio Paraná basin.

Materials examined. Vouchered materials: LIRP 15762; Sampling site G of Table 1. Non-vouchered materials: Sampling sites I, J, K, and L of Table 1.

Identification. Body elongated, laterally compressed and moderately deep, largest body depth at vertical through dorsal-fin origin. Dorsal profile of head slightly concave from tip of snout to posterior tip of supraoccipital spine. Anal-fin rays 33 or 46. Pelvic fin origin situated anterior to dorsal-fin origin. Mouth terminal, obliquely oriented relative to horizontal body axis. Teeth conical. Premaxilla with 2 teeth rows, inner row with 2 teeth oriented to interior of mouth.

***Hemigrammus marginatus* Ellis, 1911**
Figure 5I

Geographic distribution. Upper Rio Paraná basin.

Materials examined. Vouchered materials: LIRP 15746; Sampling site A of Table 1.

Identification. Terminal mouth; internal premaxilla series with 5, external series with 4 or 5. Lateral line incomplete, with 6–13 perforated scales; a longitudinal silver strip on the lateral line, which extends until the median caudal rays; with hyaline fins with yellowish base and distal third of the lobes dark.

***Hyphessobrycon bifasciatus* Ellis, 1911**
Figure 5J

Geographic distribution. Coastal river drainages from Espírito Santo to Rio Grande do Sul, Brazil and upper Rio Paraná basin.

Materials examined. Vouchered materials: LIRP 15719, 15720, 15721, 15722, and 15726; Sampling sites A, B, E, and F of Table 1.

Identification. Each premaxilla with 2 rows of teeth, the internal 1 with 4 penta- to hepta-cuspidate teeth. Caudal-fin scaleless. Lateral line incomplete. Body silver, presents 2 vertical bars at the antero-lateral body region. Seven to 12 black, V-shaped lines along the longitudinal axis of the body. No caudal spot.

***Hyphessobrycon eques* (Steindachner, 1882)**
Figure 5K

Original description. *Chirodon eques* Steindachner 1882: 179.

Geographic distribution. Amazon basin and Paraná–Paraguay system.

Materials examined. Vouchered materials: LIRP 15724, 15725, 15734, 15738, 15743, 15756, and 15779; Sampling sites A, B, C, D and E of Table 1.

Identification. Body moderately deep. Mouth terminal; inner row of premaxilla with 5 teeth, outer row with 3 or 4 teeth. Lateral line incomplete, with 4 or 5 pored scales. Ground color reddish in life, with large, transversely elongate, black humeral blotch. Pelvic, caudal, and anal fins red (the last with black margin); pectoral fin hyaline; dorsal fin with black blotch.

***Moenkhausia intermedia* Eigenmann, 1908**
Figure 5L

Original description. *Moenkhausia dichrourus intermedius* Eigenmann 1908: 103.

Geographic distribution. Upper Rio Paraná basin.

Materials examined. Vouchered materials: LIRP 15723 and 15744; Sampling sites C and F of Table 1.

Identification. Body elongated. Mouth terminal; inner row of premaxilla with 5 teeth, outer with 4, dentary with 12–14, and maxilla with 1 or 2 teeth. Lateral line complete, with 33–36 pored scales. Ground color whitish to silvery; silvery longitudinal band from posterior portion of opercle to caudal-fin base. Yellowish fins; caudal fin with black rounded blotch on each lobe and distal margins.

***Oligosarcus pintoi* Campos, 1945**
Figure 5M

Geographic distribution. Upper Rio Paraná basin.

Materials examined. Vouchered materials: LIRP 15768 and 15778; Sampling site B of Table 1. Non-vouchered materials: Sampling site C of Table 1.

Identification. Body deep. Ground color yellowish to silvery; black rounded humeral spot with diffuse dorsal and ventral extensions, followed by second, inconspicuous humeral spot; silvery longitudinal stripe on flank from humeral spot to median caudal-fin rays, widest along caudal peduncle, forming horizontally elongate blotch.

***Serrapinnus notomelas* (Eigenmann, 1915)**
Figure 5N

Original description. *Cheirodon notomelas* Eigenmann 1915: 74.

Geographic distribution. Upper Rio Paraná basin.

Materials examined. Vouchered materials: LIRP 15731, 15741, 15749, 15750, 15761, 15772, 15775 and 15781; Sampling sites A, B, C, and D of Table 1. Non-vouchered materials: Sampling site E of Table 1.

Identification. Body elongated; Mouth terminal; premaxilla with a single series of 4 or 5 teeth and maxilla with 1 or 2 teeth. Lateral line incomplete, with 5–7 pored scales. Ground color whitish; dark-brown diffuse longitudinal stripe on flank from pseudotympanum to caudal peduncle; black rounded blotch on posterior portion of caudal peduncle and caudal-fin base, not extended to median caudal-fin rays. Dorsal fin with black chromatophores along 2 unbranched and first branched rays and proximal half of remaining; pectoral, pelvic, anal, and caudal fins yellowish.

Family Crenuchidae

***Characidium zebra* Eigenmann, 1909**
Figure 5O

Geographic distribution. Upper Rio Paraná basin.

Materials examined. Vouchered materials: LIRP 15730 and 15742; Sampling site B of Table 1.

Identification. Body elongated; Mouth terminal; isthmus covered by scales; premaxilla with 9 teeth and maxilla toothless. Lateral line with 34–37 pored scales. Ground color pale yellow; dark-brown longitudinal stripe from humeral spot to caudal peduncle; eight to 10 dark-brown transverse bars on flank; black spot on the base of median caudal-fin rays.

Family Curimatidae

***Steindachnerina insculpta* (Fernández-Yépez, 1948)**
Figure 5P

Original description. *Cruxentina insculpta* Fernández-Yépez 1948: 53.

Geographic distribution. Upper Rio Paraná basin.

Materials examined. Vouchered materials: LIRP 15796; Sampling site I of Table 1. Non-vouchered materials: Sampling sites C, J, K, and L of Table 1.

Identification. Subterminal mouth; premaxilla and dentary with 4 teeth, no maxillary teeth. Ground color silvery; black conspicuous longitudinal stripe along lateral line to distal margin of median caudal-fin rays. Yellowish fins; dorsal fin 7 with few scattered black chromatophores.

Family Erythrinidae

***Hoplias malabaricus* (Bloch, 1794)**
Figure 5Q

Original description. *Esox malabaricus* Bloch 1794: 149.

Geographic distribution. Central and South America: Costa Rica to Argentina in most river basins.

Materials examined. Vouchered materials: LIRP 15737, 15740, 15748, 15751, and 15755; Sampling sites A, B, and D of Table 1. Non-vouchered materials: Sampling sites C, E, and F of Table 1.

Identification Body elongated. Rough tongue, provided with denticles. Dorsal fin with 12–15 rays. Dorsum and sides of the body with spots or irregular, sloping, sometimes V-shaped, vertex directed forward, sometimes and few distinct; head with 3 stripes behind the eyes, not always clearly visible: upper stripe ends in upper corner of operculum; median stipe sloping, terminating in lower corner of pre-operculum; and third stripe under the eyes. All fins with dark spots; sometimes in rows and forming bands.

Family Prochilodontidae

***Prochilodus lineatus* (Valenciennes, 1837)**
Figure 5R

Original description. *Paca lineatus* Valenciennes 1837: pl. 8.

Geographic distribution. Paraná-Paraguay system and Rio Paraíba do Sul basin.

Materials examined. Vouchered materials: LIRP 15800 and 15801; Sampling site I of Table 1. Non-vouchered materials: Sampling site L of Table 1.

Identification. Subterminal suctorial mouth, with spatulate teeth attached to the fleshy lips. Series of dark, wavy, horizontal stripes; 44–51 scales along the lateral line; 14–20 median predorsal scales.

Family Serrasalmidae

***Metynnis maculatus* (Kner, 1858)**
Figure 6A

Original description. *Myletes maculatus* Kner 1858: 16.

Geographic distribution. Amazon and Paraguay river basins.

Materials examined. Vouchered materials: LIRP 15735; Sampling site D of Table 1. Non-vouchered materials: Sampling site A of Table 1.

Identification. Body rounded. A ventral keel with 35–39 ventral spines. Anal fin with 35–40 rays. Presence of a dark humeral spot above the lateral line, and many rounded small spots all over the body.

***Metynnis mola* Eigenmann & Kennedy, 1903**
Figure 6B

Geographic distribution. Paraguay–Paraná river basin.

Materials examined. Vouchered materials: LIRP 15786; Sampling site N of Table 1.

Identification. Ventral keel consisting of none or 1 pair of spines, plus 17–28 single spines, 7–15 spikes with bifurcated tips and 3 or 4 pairs of spines around the urogenital opening. A black humeral spot above the lateral line; flank with many macules of approximately the same size as the pupil; maculae of dorsal region sometimes joined, forming irregular transverse bands.

***Serrasalmus maculatus* Kner, 1858**
Figure 6C

Geographic distribution. Amazon and Paraná–Paraguay system.

Materials examined. Vouchered materials: LIRP 15788; Sampling site I of Table 1.

Identification. Mouth terminal, dentary prognathous; premaxilla with 6 teeth and dentary with 7 teeth, all aligned in a cutting edge; maxilla with no teeth and palate with 4–7 teeth. Ground color silvery to yellowish, with several dark-brown rounded blotches on body. Yellowish fins; unpaired fins with distal margin black, except caudal fin, with hyaline margin, preceded by black transverse bar.

Order Cichliformes
Family Cichlidae

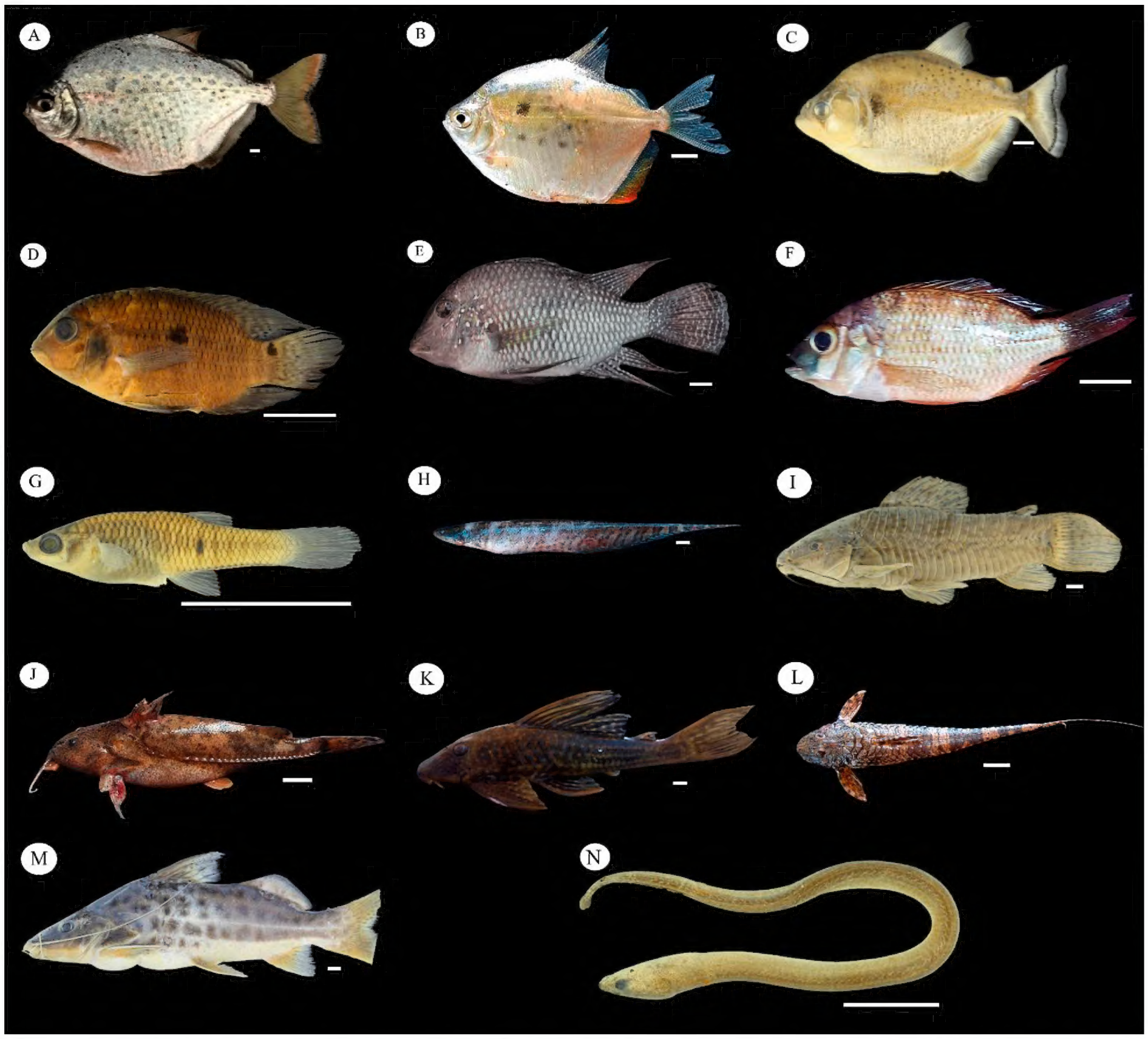

Figure 6. Representative samples of fish species collected in Rio Santa Bárbara, Sapucaí-Mirim/Grande hydrographic basin, São Paulo state, Brazil. **A.** *Metynnis maculatus*, LIRP 15735, 103.00 mm SL. **B.** *Metynnis mola*, LIRP 15786, 15.00 mm SL. **C.** *Serrasalmus maculatus*, LIRP 15788, 15.50 mm SL. **D.** *Cichlasoma paranaense*, LIRP 15732, 43.60 mm SL. **E.** *Geophagus* cf. *brasiliensis*, LIRP 15759, 138.19 mm SL. **F.** *Oreochromis niloticus*, LIRP 15789, 65.00 mm SL. **G.** *Phalloceros harpagos*, LIRP 15728, 19.93 mm SL. **H.** *Gymnotus carapo*, LIRP 15745, 240.00 mm SL. **I.** *Callichthys callichthys*, LIRP 15727, 146.03 mm SL. **J.** *Rhinodoras dorbignyi*, LIRP 15716, 111.30 mm SL. **K.** *Hypostomus* sp., LIRP 15789, 240.00 mm SL. **L.** *Rineloricaria latirostris*, LIRP 15715, 140.00 mm SL. **M.** *Pimelodus maculatus*, LIRP 15764, 230.00 mm SL. **N.** *Synbranchus marmoratus*, LIRP 15777, 72.15 mm SL. Scale bars = 1 cm.

Cichlasoma paranaense Kullander, 1983

Figure 6D

Geographic distribution. Rio Paraná basin.

Materials examined. Vouchered materials: LIRP 15732, 15736, 15739, 15770, 15776, 15782, and 15783; Sampling sites B, C and D of Table 1. Non-vouchered materials: Sampling sites A and E of Table 1.

Identification. Mouth terminal; premaxilla with 2 or 3 teeth rows, and dentary with 3 or 4 teeth rows. Upper lateral line with 14–17 pored scales, lower lateral line with 5–8 pored scales. Dorsal fin with 13–15, 10–15 and anal fin with 3, 8–10 rays. Ground color iridescent green, with dark-brown transverse bars, a dark-brown rounded blotch slightly below upper lateral line, and a dark-brown blotch on superior portion of caudal peduncle.

Geophagus cf. *brasiliensis*

Figure 6E

Geographic distribution. Upper Rio Paraná floodplain.

Materials examined. Vouchered materials: LIRP 15759, 15771, and 15797; Sampling sites A and C of Table 1. Non-vouchered materials: Sampling sites B, D, and I of Table 1.

Identification. Terminal mouth; premaxilla with 2 or 3 teeth rows, and dentary with 2–4 teeth rows; 17–19 lateral-line scales; lateral line with 1 dark-brown, rounded blotch; 7–10 anal-fin rays.

Oreochromis niloticus (Linnaeus, 1758)

Figure 6F

Original description. *Perca nilotica* Linnaeus 1758: 290.

Geographic distribution. Africa; widely introduced

everywhere (Eschmeyer et al. 2017), including Brazil.

Materials examined. Vouchered materials: LIRP 15787; Sampling site C of Table 1.

Identification. Terminal protruding mouth; premaxillary bone with 3 or more teeth rows. Lateral line interrupted, antero-superior section with 21–23 perforated scales and postero-inferior section with 13–16 perforated scales. Dorsal fins spinous and soft, with 16 or 17 spines and 11–15 soft rays.

Order Cyprinodontiformes
Family Poeciliidae

***Phalloceros harpagos* Lucinda, 2008**
Figure 6G

Geographic distribution. Rio Paraná–Paraguay system.

Materials examined. Vouchered materials: LIRP 15718, 15728, 15729, 15744, 15747, 15757, 15766, and 15784; Sampling sites A, B, D and E of Table 1. Non-vouchered materials: Sampling site F of Table 1.

Identification. Yellowish body, with gray or dark-brown, vertically elongate spot on side of body; upper region of the head darker; fins hyaline. Dorsal fin with 7– 9 rays, pelvic fin with 5 rays in males and 4 or 5 in females, anal fin with 8–10 rays in males and 10–12 in females, and pectoral fin with 5–8 branched rays.

Order Gymnotiformes
Family Gymnotidae

***Gymnotus carapo* Linnaeus, 1758**
Figure 6H

Geographic distribution. Central and South America: southern Mexico to Paraguay and including Trinidad.

Materials examined. Vouchered materials: LIRP 15745, 15758, 15773 and 15785; Sampling sites A, C and D of Table 1. Non-vouchered materials: Sampling sites E and F of Table 1.

Identification. Scales circular or slightly ovoid; mouth position superior, lower jaw longer than upper. Premaxilla with 11–16 teeth. Median margin of premaxilla curved. Maxilla-palatine articulation near anterior tip of mesopterygoid. Maxilla orientation vertical. Maxilla rod-shaped; maxilla with 4–6 dentary teeth. Dentary with 1 row of 16–19; posterior lateral line fenestra contacting dorsoposterior margin of hyomandibula. Pectoral fin with 14–16 rays. Anal fin with 217–260 rays. Multiple anal-fin ray branching posterior to rays 10–17. Lateral line ventral rami 4–27. Single hypaxial electric organ, extending along entire ventral margin of body. Three or 4 (mode 4) rows of electroplates near caudal insertion of anal fin.

Order Siluriformes
Family Callichthyidae

***Callichthys callichthys* (Linnaeus, 1758)**
Figure 6I

Original description. *Silurus callichthys* Linnaeus 1758: 307.

Geographic distribution. Widespread in South American rivers.

Materials examined. Vouchered materials: LIRP 15727; Sampling site E of Table 1. Non-vouchered materials: Sampling sites A, B, D, and F of Table 1.

Identification. Body elongated, covered by plates, with 2 rows of plates in the sides of body. Circumbital bones fully covered by skin. Mouth terminal. Lateral line with 4 pores on upper series of plates. Dorsal fin with 7 or 8 rays, pectoral with 6 rays, pelvic and anal fins with 6 rays. Ground color pale brown to dark gray. Fins dark gray with black spots.

Family Doradidae

***Rhinodoras dorbignyi* (Kner, 1855)**
Figure 6J

Original description. *Doras dorbignyi* Kner 1855: 149.

Geographic distribution. Rio Paraná–Paraguay system.

Materials examined. Vouchered materials: LIRP 15716; Sampling site K of Table 1.

Identification. Subterminal mouth; with dentigerous plates in both premaxilla and dentary bones. Lateral line with 27–28 plates; 8 or 9 anal-fin rays. Ground color yellowish; dark-brown irregular blotches on body. Hyaline or light-beige fins with dark-brown blotches and spots.

Family Loricariidae

***Hypostomus* sp.**
Figure 6K

Geographic distribution. Upper Paraná river basin.

Materials examined. Vouchered materials: LIRP 15789, 15790, and 15798; Sampling site I of Table 1. Non-vouchered materials: Sampling sites C, J, K, and L of Table 1.

Identification. Body covered with plates; mouth inferior, suction cup like. Mid-lateral series with 24–27 plates, predorsal series with 3 plates, and dorsal-fin base series with 8 plates. Ground color brownish; dark-brown blotches, occasionally inconspicuous.

***Rineloricaria latirostris* (Boulenger, 1900)**
Figure 6L

Original description. *Loricaria latirostris* Boulenger 1900: 165.

Geographic distribution. Upper Rio Paraná basin.

Materials examined. Vouchered materials: LIRP 15715; Sampling site K of Table 1.

Identification. Body dorsoventrally depressed, covered

with plates; caudal peduncle flattened. Approximately triangular head in dorsal view; mouth inferior, suction cup like. Nasal holes in the back of a pair of concavities extending from the tip of the snout to the anterior orbital margin, separated by an elevated ridge that runs from the tip of the snout to between the orbits. Post-orbital notch length equal to half the diameter of the eye. Anterior margin of the snout with a small bare area surrounded by odontoids.

Family Pimelodidae

***Pimelodus maculatus* Lacepède, 1803**
Figure 6M

Geographic distribution. Paraná and São Francisco river basins.

Materials examined. Vouchered materials: LIRP 15764, and 15765; Sampling sites I and J of Table 1. Non-vouchered materials: Sampling sites K, and L of Table 1.

Identification. Terminal mouth; presence of tooth plates in the premaxilla and dentary; absence of teeth in the vomer and metapterygoid. Ground color yellow; longitudinal series of rounded dark spots. Dark spots also distributed in the adipose and caudal fins.

Order Synbranchiformes
Family Synbranchidae

***Synbranchus marmoratus* Bloch, 1795**
Figure 6N

Geographic distribution. Drainages from Mexico to Argentina.

Materials examined. Vouchered materials: LIRP 15777; Sampling site C of Table 1. Non-vouchered materials: Sampling site E of Table 1.

Identification. Body elongated, snake-shaped; greatest body depth contained 28–32 times in SL; head length 9.0–9.3 in SL. Mouth terminal; premaxilla and dentary with several small teeth. Ground color yellowish, dorsum dark gray or brown; several dark-gray or dark-brown spots on body.

Discussion

Over the last 80 years, the Rio Santa Bárbara basin has suffered with the intensification of the use of its catchment area for agricultural activities. In the middle of the last century, the main economic activities were cattle-raising, coffee cultivation, and mining activity, with an emphasis on diamond mining, and all these anthropic activities developed in the region triggered significant impacts on riverbeds (Vieira 1985). Currently, the region is occupied almost exclusively by the cultivation of sugar cane, with the intensive use of agrochemicals in sugarcane cultivation, which can cause contamination of the soil and be carried to the water bodies. Another practice widely used in sugarcane cultivation is fertigation with vinasse. This practice can be characterized as a potential source of water bodies pollution, due to the high presence of toxic metals in its composition (Fues 2013).

In this work, the first inventory carried out in the Rio Santa Bárbara, 32 fish species were identified, which is consistent with other surveys carried in smaller rivers in the northern part of the state of São Paulo, such as Castro et al. (2004) and Lemes (2002), where 52 and 21 species were identified, respectively. Rio Sapucaí-Mirim basin has 105 species already identified, according to surveys made by Castro et al. (2004), Cezário (2010), Souza (2014), and Brambilla (2016). According to the data collected throughout this work, the fish fauna community of the Santa Bárbara River and its marginal lakes diverge from the pattern reported in other similar studies, where the predominance of Characiformes and Siluriformes in order of 80% for the upper Rio Paraná basin have been reported (Langeani et al. 2007). The presence of migratory species (*Megaleporinus obtusidens*, *Pimelodus maculatus*, *Prochilodus lineatus*, and *Salminus hilarii*) was confirmed during our fieldwork, which allows us to hypothesize that these species are overcoming artificial barriers between the feeding and the breeding areas.

Only 2 alien species were found in Rio Santa Bárbara basin, being one allochthonous (*Metynnis maculatus*) and one exotic (*Oreochromis niloticus*), which represents only 0.7% of the total specimens collected in this basin. This is a relevant fact, since the introduction of species is considered one of the main vectors of biodiversity loss worldwide (Machado 2008).

During the expeditions, four specimens of *Metynnis mola* were collected in an unselected lake (20°42.36′S, 047°20.77′W) and 1 specimen of *Brycon nattereri* was collected in a region of the Rio Santa Bárbara upstream of the collection sites (20°42.05′S, 047°13.31′W). The *Brycon naterreri* species is Critically Endangered in the state of São Paulo. In the present study, 3 species not yet found in Rio Sapucaí-Mirim basin were collected: *Hyphessobrycon bifasciatus*, *Moenkhausia intermedia*, and *Brycon nattereri*.

Finally, considering that the region still has significant remnants of original vegetation, the large number of marginal lakes, the diversity of fish found, the identification of an endangered species (e.g. *Brycon nattereri*), target species of PAN MPSG, and the collection of 4 species of migratory fishes, the need to create a conservation unit, preferably a federal one, should be evaluated, since Rio Santa Bárbara has its origins in the state of Minas Gerais and runs through 3 cities in the state of São Paulo until its confluence with Rio Sapucaí-Mirim. The creation of a conservation unit is justified by the possibility of bringing more technical and financial resources, with the objective of protecting the region from environmental degradation, predatory fishing and environmental pollution in Rio Santa Bárbara basin and its surroundings, contributing to a better scientific knowledge of the region.

Acknowledgements

We express our very appreciation to the institutions that supported this work, without which it would not be possible to carry on this paper: IBB - Unesp Botucatu; Coordination of MPSG PAN, ICMBio/CEPTA; LIRP/USP; and Uni-Facef. We especially thank Hur Siqueira Filho for the help with preparing the images. We also thank LIRP and USP specialists for their help with identifying some species.

Authors' Contributions

PBD, HOS, TOF, NFP and CB collected the specimens; PBD, ALHE and HOS identified the specimens; ALHE, HOS and TOF photographed the specimens; PBD, TOF and JAS wrote the manuscript; all authors reviewed the text.

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